(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 952 245 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
27.10.1999 Bulletin 1999/43

(51) Int. Cl.[6]: D01H 1/244, D01H 1/32, D01H 13/16, B65H 63/02

(21) Application number: 99103544.5

(22) Date of filing: 24.02.1999

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 27.03.1998 JP 8092898
16.04.1998 JP 10601998

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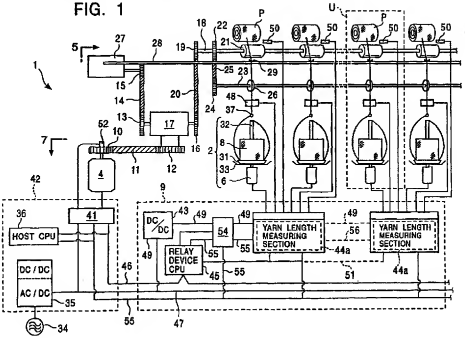
# (54) Individual-spindle-drive type multi-twister

(57) To provide an inexpensive individual-spindle-drive type multi-twister that has a simple structure and can prevent malfunctions when used with fiber dust.

The present invention relates to an individual-spindle-drive type multi-twister 1 that has a spindle drive motor 6 for every spindle 2 for twisting yarn and creates a winding package P from a yarn supply package 8 which is provided for each spindle 2. Each spindle drive motor 6 is driven by means of a rotation speed control apparatus 44. The twister 1 is characterized in that it comprises a yarn-run judgment means 44b to determine whether yarn is running from the state of each spindle drive motor 6, and a yarn length measuring means 44a for performing yarn length measurement using the yarn running signal of the yarn-run judgment means 44b.

FIG. 1



## Description

### Field of the Invention

[0001] The present invention relates to a multi-twister for twisting and winding yarn unwound from a yarn supply package. In particular, the present invention relates to a individual-spindle-drive type multi-twister provided with a yarn length measuring mechanism.

### Background of the Invention

[0002] A conventional multi-twister, as shown in Figure 9, comprises a plurality of multi-twisting units having a spindle apparatus 101a and a winding apparatus 101b. This multi-twisting unit has a driving mechanism 110 that drives a winding drum 106, a traverse guide 107, and a spindle 103. This spindle apparatus 101a is designed to twist yarn by transmitting the driving force of a drive motor 113 to the spindle 103 by means of a belt 104. In addition, the winding apparatus 101b is designed to wind a winding package 105 while the yarn twisted by means of the spindle apparatus 101a is traversed by means of the traverse guide 107 via a feed roller 108.

[0003] The above driving mechanism 110 essentially comprises the drive motor 113, a plurality of pulleys 111, 112, 115, 116, 117, and 119, and bolts 104 and 118 so that the winding drum 106, the traverse guide 107, and the spindle 103 is driven by means of a single drive motor 113. The output of the drive motor 113 is transmitted to the running belt 104 via an output shaft 114, the third pulley 115, the belt 118, the fifth pulley 117, and the first pulley 111, and the spindle 103 is thus driven. In addition, the winding drum 106 is driven when the output of the drive motor 113 is transmitted through the output shaft 114, the fourth pulley 116, the belt 120, the sixth pulley 119, a speed change belt apparatus 150, a speed reducing box 123, and a belt 130. Further, the traverse guide 107 moves reciprocally when rotation of a support shaft 126 is transmitted to a grooved drum 137 via a belt 134 and a cam shoe 139 is moved along a groove 138 by rotation of that grooved drum 137.

[0004] Like a conventional multi-twister, however, when the spindle apparatus 101a and the winding apparatus 101b are driven by means of the single drive motor 113, a plurality of pulleys are rotated by means of belts 104 and 120, resulting in large mechanical losses and excessive power consumption. To overcome this problem, a individual-spindle-drive type multi-twister has been developed wherein the spindle driving system and the winding drum driving system are driven by another motor, and wherein a spindle driven motor is provided for each spindle unit so as to drive the spindle apparatuses independently. This individual-spindle-drive type multi-twister requires a yarn length measuring function only in the case where a plurality of winding packages are formed from a single large-sized yarn supply package. In such an individual-spindle-drive type multi-twister with small divided winding package, conventionally, yarn length measurement is performed by means of a photoelectric filler, which detects the yarn run state, and the rotation speed of the drum.

[0005] Conventionally, individual-spindle-drive type multi-twisters using photoelectric fillers for yarn length measurement tend to malfunction caused by fiber dust. Moreover, if yarn length measurement is performed by means of the photoelectric filler, the equipment configuration is complicated and manufacturing costs are high.

[0006] The present invention has been developed in view of the above problems. It is an object of the present invention to provide an inexpensive individual-spindle-drive type multi-twister that has a simple structure and can prevent malfunctions caused by fiber dust.

### Summary of the Invention

[0007] The present invention relates to a individual-spindle-drive type multi-twister that has a spindle drive motor for every spindle to twist yarn, and each spindle drive motor is driven by means of a rotation speed control apparatus, and a winding package is formed from a yarn supply package provided for each spindle. The multi-twister has a yarn-run judgment means that determines whether yarn is running from the state of each spindle drive motor. The multi-twister also has a yarn length measuring means that performs the yarn length measurement using the yarn running signal of the yarn-run judgment means.

[0008] Thereby, the need for a yarn filler comprising an optical yarn running detector can be eliminated, thus making it possible to prevent malfunctions caused by fiber dust and reduce the manufacturing costs of the individual-spindle-drive type multi-twister. In addition, the individual-spindle-drive type multi-twister engages with the running yarn so that it eliminates the need for a drop wire mechanism for stopping the yarn feeding from the yarn supply package when the yarn is cut, thus making it possible to simplify the machine's structure.

[0009] The present invention is characterized in that the yarn-run judgment means determines whether yarn is running from the load current value of each spindle drive motor. Thereby, it is possible to determine whether the spindle is rotating, thus making it possible to accurately determine the yarn running state. In a state in which the spindle is rotating, the yarn is always wound and running.

[0010] The present invention is characterized in that it comprises a cutter means for cutting yarn that is being wound. In the present invention, when a winding package is detected as "full bobbin " by the yarn length measuring means, a full bobbin detection means outputs a cutter actuation signal to the cutter means and outputs a spindle drive motor stop signal.

[0011] Thereby, only a spindle drive motor which engages a full bobbin winding package can be stopped

individually, thus making it possible to eliminate wasteful spindle rotation and wind the yarn efficiently.

**[0012]** The present invention is characterized in that the yarn-run judgment means sets a threshold value based on a load current value under a stable condition after the load current value of each spindle drive motor has been stabilized, and detects the yarn breakage when the detected load current value exceeds its threshold value.

**[0013]** The present invention is characterized in that the yarn-run judgment means always monitors the variation in load current value at a predetermined time, and detects the yarn breakage based on the scale of that variation.

**[0014]** The present invention is characterized in that the rotation speed control apparatus obtains an output of a instruction value based on the difference between the detected rotation speed and the target rotation speed for each spindle drive motor, and accordingly performs feedback control, moreover, the yarn-run judgment means detects the yarn breakage based on acute fluctuations in the detected rotation speed or the amount of output.

Brief Description of the Drawing

**[0015]**

Figure 1
A schematic view of an individual-spindle-drive type multi-twister according to the first embodiment of the present invention.

Figure 2
A schematic view of a winding apparatus and a spindle apparatus with respect to the individual-spindle-drive type multi-twister of Figure 1.

Figure 3
A block diagram for illustrating the individual-spindle-drive type multi-twister of Figure 1.

Figure 4
A block diagram for illustrating a yarn length measuring system with respect to the individual-spindle-drive type multi-twister of Figure 1.

Figure 5
A flowchart for illustrating the operation of the yarn length measuring system with respect to the individual-spindle-drive type multi-twister of Figure 1.

A schematic view of a individual-spindle-drive type multi-twister according to the second embodiment.

Figure 7
A schematic view of a winding apparatus and a spindle apparatus with respect to the individual-spindle-drive type multi-twister of Figure 6.

Figure 8
A block diagram for illustrating a problem detecting system with the individual-spindle-drive type multi-twister of Figure 6.

Figure 9
A schematic view of a conventional multi-twister.

Detailed Description of the preferred Embodiments

**[0016]** Hereinafter, a first embodiment of the present invention will be described by referring to the accompanying drawings.

**[0017]** An individual-spindle-drive type multi-twister 1, as shown in Figure 1, structured so that a yarn winding units U of 80 to 308 spindles are arranged in a line. Each yarn winding unit U has a spindle apparatus 2 and a winding apparatus 3 successively provided thereon so as to wind the yarn of a single yarn supply package 8 around a winding package P.

**[0018]** The above spindle apparatus 2 has the yarn supply package 8, a stationary plate 31, a tension apparatus 32, a rotary disk 33, and a spindle drive motor 6, so as to twist yarn Y by means of the spindle drive motor 6. In this spindle drive motor 6, a DC brushless motor BLM is employed, and its output shaft is provided with the rotary disk 33. In addition, the rotary disk 33 is provided with the stationary plate 31 so that a single yarn supply package 8 can be placed on the stationary plate 31. Further, the tension apparatus 32 is provided at the upper part of the yarn supply package 8 so that the tension apparatus 32 imparts a predetermined tension to the yarn Y unwound from the yarn supply package 8.

**[0019]** Thereby, the spindle apparatus 2 inserts yarn Y unwound from the yarn supply package 8 to the tension apparatus 32 and imparts a tension during which the rotary disk 33 is rotated at a high speed by means of the spindle drive motor 6. The yarn Y is ballooned to a balloon guide 37. In addition, the yarn Y is twisted once from the tension apparatus 32 to the rotary disk 33, and is twisted once more from the rotary disk 33 to the balloon guide 37.

**[0020]** The above winding apparatus 3, as shown in Figure 2, has a winding drum 21, a winding package P, a traverse guide 29, a feed roller 26, and a cradle 40 so as to wind the yarn Y twisted by the spindle apparatus 2 around the winding package P. The winding package P pivots around the above cradle 40, and the winding drum 21 is brought into pressure contact with the winding package P. Thereby, the winding apparatus 3 winds the yarn Y, which is twisted twice in total, as shown above around the winding package P, while the yarn Y is traversed by the traverse guide 29 via the balloon guide 37, the guide rollers 38 and 39 and the feed roller 26.

[0021] A cutter 48 is provided between the balloon guide 37 and the guide roller 38 so as to cut the yarn Y when the cutter 48 receives a cutter actuation signal. In addition, the above winding drum 21 is provided with a winding drum rotation speed detector 50 for detecting its rotation speed, and is connected to an inverter 44 for a spindle drive motor described later (refer to Figure 1).

[0022] In addition to the above yarn winding unit U, the above individual-spindle-drive type multi-twister, as shown in Figure 1, has a drivr system 5 for driving the winding apparatuses 3 all together and a control system 7 for controlling each of the spindle apparatuses 2 and each of the winding apparatuses 3. This drive system 5 has a winding drum drive motor 4, a first pulley 10, a belt 11, a second pulley 12, a decelerator 17, a third pulley 16, a fourth pulley 19, a belt 20, a fifth pulley 22, a sixth pulley 24, a seventh pulley 13, a belt 14, an eighth pulley 15, and a cam box 27. The winding drum 21 and the feed roller 26 of each yarn winding unit U are rotated, and the traverse guide 29 is caused to move reciprocally by means of the driving force of the winding drum drive motor 4.

[0023] The above winding drum drive motor 4 is an induction electric motor IM. The first pulley 10 is provided at its output shaft, and the second pulley 12 is provided via the belt 11. The above decelerator 17 has a plurality of gears (not shown in the drawings). When the driving force of the winding drum drive motor 4 is transmitted via the second pulley 12, the decelerator 17 is decelerated at a constant rate. At the same time, the rotational direction of the decelerator 17 is changed. In addition, the decelerator 17 has two output shafts so as to provide two-shaft output from a single input. The third pulley 16 engages a single output shaft, and the seventh pulley 13 engages the other output shaft.

[0024] The fourth pulley 19, which is engaged with a support shaft 18, is disposed near the third pulley 16, and at the support shaft 18, a plurality of winding drums 21 are provided at predetermined intervals. In addition, the fifth pulley 22 engages the above support shaft 18 in a line to the fourth pulley 19.

[0025] This fifth pulley 22 connects to the sixth pulley 24, which engages the support shaft 23, via the belt 25, and at the support shaft 23, a plurality of feed rollers 26 are provided at predetermined intervals. Thereby, the drive system 5 transmits a driving force decelerated by the decelerator 17 to each winding drum 21 via the third pulley 16, the belt 20, and the fourth pulley 19, and transmits this force to the feed rollers 26 via the fifth pulley 22, the belt 25, and the sixth pulley 24.

[0026] The decelerator 17 is coupled with the cam box 27 via the seventh pulley 13, the belt 14, and the eight pulley 15. The reciprocating rod 28 is coupled with this cam box 27 so as to convert the rotational force into reciprocating motion. The traverse guide 29 engages this reciprocating rod 28 at a predetermined interval. The drive system 5 causes the traverse guide 29 to move back and forth so as to wind the yarn Y twisted by the spindle apparatus 2 around the rotating winding package P that is in pressure contact with the winding drum 21 while the yarn Y is traversed.

[0027] The above control system 7, as shown in Figure 3, has a main control apparatus 42 and a plurality of unit control sections 9 for controlling each spindle apparatus 2, and thus constitutes the overall control system for the individual-spindle-drive type multi-twister 1. The above main control apparatus 42 has a converter 35 that converts the voltage from an AC power source 34, a host CPU 36 constituting a central control apparatus, and a rotation speed control apparatus 41 for a winding drum drive motor. In this way, various control instructions are output simultaneously to each of the unit control sections 9 and the rotation speed control apparatus 42 for the winding drum drive motor.

[0028] The above host CPU 36 simultaneously transmits various parameters and control instructions to each unit control section 9 and the rotation speed control apparatus 41 for the winding drum drive motor directly via a communication line 46. The host CPU 36 simultaneously transmits start/stop instructions to each unit control section 9 and the rotation speed control apparatus 41 for the winding drum drive motor directly via a control signal line 55. In addition, the converter 35 has an AC/DC conversion section 35a and a DC/DC conversion section 35b. The rotation speed control apparatus 41 for the winding drum drive motor is connected to the AC/DC conversion section 35a via a direct current bus 47. The host CPU 36 is connected to the DC/DC conversion section 35b so as to convert a direct current voltage of 290 volts to a direct current voltage of 24 volts for use as a control system voltage for the host CPU 36.

[0029] The above rotation speed control apparatus 41 for the winding drum drive motor receives a direct current voltage of 290 volts via the direct current bus 47, and uses a control instruction or parameter received via the communication line 46 so as to send feedback to control the winding drum drive motor 4 independently based on the rotation speed generated by a pulse generator PG52. When the control instruction is received, the winding drum drive motor 4 is controlled independently by feedback depending on the rotation speed from the pulse generator PG52 so as to drive and stop the winding drum drive motor 4.

[0030] Each unit control section 9 has 32 rotation speed control apparatuses 44 for the spindle drive motor, a relay 45, and a direct current transformer 43 for the spindle apparatus. They are connected to the main control apparatus 42 in a line via the communication line 46. To this relay 45, 32 rotation speed control apparatuses 44 are connected via a communication line 51, and the relay 45 relays a control instruction output by the host CPU 36 so as to transmit the instruction to each of the 32 rotation speed control apparatuses 44.

[0031] Each of the above direct current transformers 43 for the spindle apparatus is connected to the direct current bus 47 so as to convert a direct current voltage

of 290 volts supplied via the direct current bus 47 to a direct current voltage of 24 volts during normal operation. This lower voltage is used as a control system voltage in controlling the spindle drive motor 6.

[0032] Each of the above 32 rotation speed control apparatuses 44 for the spindle drive motors is connected in series to the direct current transformer 43 for the spindle device via a control power supply line 49. Between each of the 32 rotation speed control apparatuses and the direct current transformer 43 for spindle apparatuses, a relay connector board 54 is disposed. The control power supply line 49 is connected to the rotation speed control apparatus group and the relay 45 via the direct current transformer 43 for the spindle apparatus and relay connector board 54. Two spindle drive motors 2 are connected to each rotation speed control apparatus 44. Each rotation speed control apparatus 44 can receive a control instruction via the communication line 46, the relay 45, and the communication line 51 so as to send feedback to control each spindle drive motor 6 independently based on the rotation speed from the rotation speed detector 53. That is, two spindle drive motors 6 are driven and stopped by means of a single rotation speed control apparatus 44. Each of the rotation speed control apparatuses 41 and 44 drives and stops each of the motors 4 and 6 respectively.

[0033] Now, essential aspects of the multi-twister 1 according to this embodiment will be described.

[0034] As shown in Figures 3 and 4, the above rotation speed control apparatus 44 for spindle drive motors has a yarn length measuring section 44a constituting a yarn length measuring means, a motor control section 44d, and an input current detection section 44e so as to measure a length of yarn Y wound around a winding package P. This yarn length measuring section 44a has a yarn-run judgment section 44b constituting a yarn-run judgment means and a full bobbin detection section 44c constituting a full bobbin detection means so as to detect a full bobbin of the winding package P in addition to yarn length measurement.

[0035] The above yarn-run judgment section 44b monitors a instruction current value Sg1 (the load current value of the spindle drive motor 6) to the spindle drive motor 6. When that current value Sg1 is above a predetermined value, the yarn-run judgment section 44b determines that yarn is running, and continues to output the yarn running signal Sg2 to the full bobbin detection section 44c. In addition, the above full bobbin detection section 44c counts the winding drum rotation signals (pulse signal) Sg3 generated by a winding drum rotation speed-detector 50, thus providing a means for detecting rotation when the yarn is running. If a predetermined count corresponding to a full bobbin is reached, a "full bobbin" judgment is made. That is, the full bobbin detection section 44c detects a full bobbin of the winding package P by means of the yarn running signal Sg 2 and the winding drum rotation signals Sg 3. If the bobbin is considered to be full, the full bobbin detection section 44c outputs a cutter actuation signal Sg4 to the cutter 48, which constitutes a cutter means, and outputs a stop motor signal Sg5 to a spindle drive motor control section 44d.

[0036] The operation of the individual-spundle-drive type multi-twister 1 according to the above configuration will be described with reference to the accompanying drawings.

[0037] As shown in Figure 1, a direct current voltage of 24 volts is supplied from the alternating current power source 34 to each rotation speed control apparatus 44 via the converter 35, the direct current bus 47, and the direct current transformer 43 for the spindle apparatus. In addition, a start instruction is transmitted from the host CPU 36 to each relay connector board 54 via the control signal line 55, and simultaneously supplied from each relay connector board 54 to the rotation speed control apparatuses 44 for spindle drive motors via the control signal line 56. Each spindle drive motor 6 is driven by the start instruction from its corresponding rotation speed control apparatus 44, and each rotary disk 33 rotates at a rotation speed identical to that of the corresponding spindle drive motor 6. When each rotary disk 33 rotates, the yarn unwound from the yarn supply package 8 enters the tension apparatus 32. The yarn Y is twisted once while a tension is applied, is further twisted once more, and is ballooned to the balloon guide 37.

[0038] . On the other hand, a direct current voltage of 290 volts is supplied from the alternating current power source 34 to the rotation speed control apparatus 41 for the winding drum drive motor via the direct current bus 47, and a start instruction is transmitted from the host CPU 36 to the rotation speed control apparatus 41 via the control signal line 55. The winding drum drive motor 4 is driven based on a start instruction from the rotation speed control apparatus 41, and the output of the winding drum drive motor 4 is transmitted to the support shafts 18 and 23 and the reciprocating rod 28 via the pulleys 10, 12, 16, 19, 22, and 24, the belts 11, 14, 20, and 25, the decelerator 17 and the cam box 27. Then, the winding drum 21 and the feed roller 26 rotate, and the traverse guide 29 of each spindle reciprocates.

[0039] When the winding drum 21 for each spindle and the feed roller 26 rotate and the traverse guide 29 of each spindle reciprocates, the yarn Y twisted twice bythe spindle apparatus 2 is traversed by means of the traverse guide 29, and is then wound around the winding package P. During the traversing process, the winding angle is corrected by means of the decelerator 17.

[0040] Thus, while the yarn Y is wound around the winding package P, as shown in Figures 4 and 5, the yarn-run judgment section 44b determines (S1) whether the yarn Y is continuously run from a instruction current value Sg1 (whether the yarn Y is wound around the winding package P). When it is determined that the yarn is running (S1, YES), the yarn running signal Sg2 is output to the full bobbin detection section

44c. The full bobbin detection section 44c captures a rotation signal Sg3 from the winding drum rotation detector 50 and performs yarn length measurement (predetermined length counting) while it receives the yarn running signal Sg2 (S2). The full bobbin detection section 44c outputs a cutter actuation signal Sg4 to the cutter 48, and outputs a stop motor signal Sg5 to the motor control section 44d when it determines that the winding package P is a full bobbin (S3, YES). When the cutter 48 receives a cutter actuation signal Sg4 from the cutter solenoid, the cutter 48 cuts the yarn Y (S4).

**[0041]** On the other hand, when the motor control section 44d receives a stop motor signal Sg5, it stops the spindle drive motor 6 (S5). When the spindle drive motor 6 stops, the cradle 40 rises, and the winding package P leaves the winding drum 21 (S6). The full bobbin winding package P is replaced with a new winding package P, and yarn threading is performed by a yarn threading device (not shown in the drawings) (S7). When winding is restarted (S8, YES), process control reverts from S8 to S1. In S8, when winding is not restarted (S8, NO), operation is terminated (END).

**[0042]** In S1, if an yarn breakage or the like occurs, when the yarn-run judgment section 44b determines that the yarn Y is not running (S1, NO), it outputs a stop motor signal to the motor control section 44d via the full bobbin detection section 44c, and stops the spindle drive motor 6 (S9). When the spindle drive motor 6 stops, process control shifts from S9 to S1 through an ending process or the like (S10).

**[0043]** In S3, if the full bobbin detection section 44c determines that the winding package P is not a full bobbin, (S3, NO), process control shifts from S3 to S1, and S1 continues yarn length measurement.

**[0044]** The control power supply line 49 of the multi-twister 1 according to this embodiment supplies to each rotation speed control apparatus 44 a control system voltage (24 volts) for controlling the spindle drive motors 6. In addition, the control signal lines 55 and 56 serve to transmit a start instruction or a stop instruction to all of the rotation speed control apparatuses 41 and 44 and transmit a simultaneous start or stop signal for the ordinary machine. Further, the communication lines 46 and 51 serve to monitor the rotation speed of each motor 6, the instruction value for each motor 6, or the like through the host CPU 36. These lines 46 and 51 apply control parameters from the host CPU 36 to the rotation speed control apparatuses 41 and 44.

**[0045]** In this embodiment, the yarn Y is twisted while it is ballooned around the yarn supply package 8, therefore, the instruction current value Sg1 for the spindle drive motor 6 increases due to a high balloon tension. If a yarn breakage occurs, that balloon tension is eliminated, therefore, the instruction current value Sg1 decreases, and detecting this decrease makes it possible to determine whether the yarn Y is running.

**[0046]** Specifically, after the instruction current value Sg1 is stabilized, for example, a threshold value is set based on the current value Sg1 in that stabilized state, and a yarn breakage can be detected if that threshold value is exceeded. In addition, a fluctuation in the current value Sg1 at a predetermined time is monitored continuously, making it possible to detect a yarn breakage based on the degree of fluctuation. Further, the yarn running may be determined by means of a detected rotation speed or an output (duty ratio) of the instruction valve, instead of the current value Sg1. A rotation speed detector 53 is incorporated in a DC brushless motor, making it possible to obtain the detected rotation speed by means of a detection signal from the detector 53.

**[0047]** That is, in this embodiment, the rotation speed of the motor 6 is detected, an output of the instruction value is obtained from the difference between the detected rotation speed and the target rotation speed, and feedback control is performed. Therefore, the detected rotation speed and output basically remain within a predetermined range during normal winding. If a yarn breakage occurs, acute fluctuations are detected. Consequently, the yarn running can be determined by detecting such yarn breakage.

**[0048]** If the current value Sg1, the detected rotation speed, or output exceeds a normal range, the motor 6 is stopped immediately. Therefore, the yarn running may be determined based on whether the motor 6 is rotating (whether the motor 6 is rotating above a predetermined rotation speed).

**[0049]** Hereinafter, an individual-spindle-drive type multi-twister capable of accurately and speedily detecting problems such as incorrect yarn winding will be described according to a second embodiment of the present invention.

**[0050]** In an individual-spindle-drive type multi-twister provided with a drive motor for each spindle, when a host central control apparatus determines that a plurality of spindle apparatuses have failed, the central control apparatus is overburdened with monitoring responsibilities, and problems such as delayed recognition of incorrect yarn winding, detection errors, or the like may result.

**[0051]** In this embodiment, the individual-spindle-drive type multi-twister which is provided with a drive motor for each spindle for applying a twist to yarn is equipped with a rotation speed control apparatus for detecting the rotation speed of each drive motor. The rotation speed control apparatus performs feedback control individually in order to keep the rotation speed at the target speed. The apparatus also has a problem judgment means for determining problems for each individual spindle. In the case where the rotation speed of the drive motor is controlled by feedback so as to keep it at a target speed, problems are detected using the measurements of that rotation speed, thus making it possible to speedily detect problems such as incorrect yarn winding. In addition, the motor rotation speed is strictly maintained to the target speed by means of feedback control. There-

fore, even in cases where the threshold value (a criterion for determining whether there is a problem) is set to a position very close to the target speed, significant problems such as incorrect yarn winding can be detected speedily.

**[0052]** In the case where a instruction value is simply output based on a problem without performing feedback control, it is often the case that the actual rotation speed is not stabilized due to a variety of indirect causes. For detecting problems based on that rotation speed, it is necessary to set a threshold value (problem judgment criterion) at a position having a certain difference from the target speed in order to avoid wasteful problem recognition.

**[0053]** In each rotation speed control apparatus, a judgment ratio value can be set and input to obtain the threshold value used as a criterion. The problem judgment means should preferably set a normal range for the input judgment ratio valve and target speed, and determine problems depending upon whether the detected rotation speed exceeds the normal range. Thereby, a normal range is automatically set to a variety of target speeds merely by presetting the judgment ratio value. Even in the case where the target value is changed, it is possible to effectively detect problems without resetting the normal range.

**[0054]** A plurality of rotation speed control apparatuses can be provided along the length of the machine. Each rotation speed control apparatus is connected to one central control apparatus via common communication lines, making it possible to set and input the judgment ratio value to the central control apparatus and pass those settings directly to each rotation speed control apparatus. Each rotation speed control apparatus should have a transmission means for transmitting a warning signal to the central control apparatus via the communication lines if a problem is detected by problem judgment means. Thereby, the judgment ratio value can be easily set and input to a number of rotation speed control apparatuses via the communication lines. At the same time, the warning signal is transmitted to the central control apparatus via the same communication lines, thereby making it possible to broadcast the occurrence of problems to the central control unit immediately.

**[0055]** Hereinafter, a specific configuration of the second embodiment will be described in reference to Figures 6 to 8. According to this embodiment, in the individual-spindle-drive type multi-twister, as shown in Figure 6, yarn winding units U of 80 to 308 spindles are arrayed and configured. A yarn winding unit U has the spindle apparatus 2 and a winding apparatus 3 successively disposed thereon so as to wind yarn of a single yarn supply package 8 around the winding package P.

**[0056]** The above spindle apparatus 202 has a yarn supply package 208, a stationary plate 231, a tension apparatus 232, a rotary disk 233, and a spindle drive motor 206 so as to twist yarn Y by means of the spindle drive motor 206. This spindle drive motor 206 uses a DC brushless motor BLM, and the rotary disk 233 is disposed at its output shaft. In addition, the rotary disk 233 is provided with the stationary plate 231 so as to enable one yarn supply package 208 to be placed on the stationary plate 231. Furthermore, the tension unit 232 is provided at the upper part of the yarn supply package 208 so that the tension apparatus 232 applies a predetermined tension to the yarn Y unwound from the yarn supply package 208.

**[0057]** Thereby, the spindle apparatus 202 rotates the rotary disk 233 at high speed via the spindle drive motor 206 so as balloon the yarn Y to a balloon guide 237 while the spindle apparatus 202 inserts the yarn Y unwound from the yarn supply package 208 into the tension apparatus 232 to apply a tension. In addition, the yarn Y is twisted once when passing from the tension apparatus 232 to the rotary disk 233, and twisted once more when passing from the rotary disk 233 to the balloon disk 237.

**[0058]** Moreover, as shown in Figure 7, the above winding apparatus 203 has a winding drum 221, a winding package P, a traverse guide 229, a feed roller 226, and a cradle 240 so as to wind the yarn Y twisted by the spindle apparatus 202 around the winding package P. The winding package P pivots around the above cradle 240, and the winding drum 221 is brought into pressure contact with the winding package P. Thereby, the winding apparatus 203 is designed to wind the yarn Y, which is twisted twice as described above, around the winding package P while the traverse guide 229 traverses the yarn Y from the balloon guide2 37 via the guide rollers 238 and 239 and the feed roller 226.

**[0059]** In addition to the above yarn winding unit U as shown in Figure 6, the above individual-spindle-drive type multi-twister 201 has a drive system 205 for driving each winding apparatus 203 simultaneously and a control system 207 for controlling each spindle apparatus 202 and each winding apparatus 203. This drive system 205 has a winding drum drive motor 204, a first pulley 210, a belt 211, a second pulley 212, a decelerator 217, a third pulley 216, a fourth pulley 219, a belt 220, a fifth pulley 222, a sixth pulley 224, a seventh pulley 213, a belt 214, an eight pulley 215, and a cam box 227 so as to rotate the winding drum 221 of each yarn winding unit U and the feed roller 226 and reciprocate the traverse guide 229 using the driving force of the winding drum drive motor 204.

**[0060]** The above winding drum drive motor 204 is an induction motor IM. The motor 204 has the first pulley 210 at its output shaft, this pully 210 connects to a second pulley 212 via the belt 211. The above decelerator 217 has a plurality of gears (not shown in the drawings). When the driving force of the winding drum drive motor 204 is transmitted via the second pulley 212, the decelerator 217 is decelerated at a constant rate, and at the same time, the rotational direction of rotation is changed. In addition, the decelerator 217 has two out-

put shafts so that two-shaft output can be generated from a single input. The third pulley 216 engages one output shaft, and the seventh pulley 213 engages the other output shaft.

[0061] The above third pulley 216 connects to the fourth pulley 219 which engages the support shaft 218 via the belt 220. Along the support shaft 218 a plurality of winding drums 221 are disposed at predetermined intervals. In addition, the fifth pulley 222 engages the above support shaft 218 in a line to the fourth pulley 219. This fifth pulley 222 connects to the sixth pulley 224 which engages the support shaft 223 via the belt 225. Along the support shaft 223 a plurality of feed rollers 226 are disposed at predetermined intervals. Thereby, the drive system 205 transmits a driving force decelerated by the decelerator 217 to each winding drum 221 via the third pulley 216, the belt 220, and the fourth pulley 219, and transmits this force to the feed rollers 226 via the fifth pulley 222, the belt 225, and the sixth pulley 224.

[0062] In addition, the above decelerator 217 is coupled to the cam box 227 via the seventh pulley 213, the belt 214, and the eight pulley 205. A reciprocating rod 228 is coupled to this cam box 227 so as to convert a rotational force into reciprocating motion. The traverse guide 229 engages this reciprocating rod 228 at a predetermined interval. Thus, the drive system 205 reciprocates the traverse guide 229 so as to wind the yarn Y twisted by the spindle apparatus 202 around the winding package P, which, while the yarn Y is traversed, rotates due to pressure contact with the winding drum 221.

[0063] The above control system 207, as shown in Figure 8, has a main control apparatus 242 and a plurality of unit control sections 209 for controlling each spindle apparatus 202, and thus constitutes a control system for an individual-spindle-drive type multi-twister 201. The above main control apparatus 242 has a converter 235 for converting a voltage generated by an alternate current power source 234, a host CPU 236 constituting a central control apparatus, and a rotation speed control apparatus 241 for the winding drum drive motor so as to simultaneously output various control instructions to each unit control section 209 and a rotation speed control apparatus 241 for the winding drum drive motor.

[0064] The above host CPU 236 simultaneously transmits various parameters and control instructions to each unit control section 209 and the rotation speed control apparatus 241 for the winding drum drive motor directly via a communication line 246. In addition, the host CPU 236 simultaneously transmits start and stop instructions to each unit control section 209 and the rotation speed control apparatus 241 for the winding drum drive motor directly via a control signal line 254. Further, the converter 235 has an AC/DC conversion section 235a and a DC/DC conversion section 235b. The rotation speed control apparatus 241 for the winding drum drive motor is connected to the AC/DC conversion section 235a via a direct current bus 247. The host CPU 236 is connected to the DC/DC conversion section 235b. The DC/DC conversion section 235b is designed to convert a direct current voltage of 290 volts to a direct current voltage of 24 volts for use by the host CPU 236 as a control system voltage.

[0065] The above rotation speed control apparatus 241 for the winding drum drive motor receives a direct current voltage of 290 volts via the direct current bus 247, and uses control instructions and parameters received via the communication line 246 so as to send feedback to control the winding drum drive motor 204 independently based on the rotation speed generated by a pulse generator PG252.

[0066] Each unit control section 209 has 32 rotation speed control apparatuses 244 for spindle drive motors, a relay 245, and a direct current transformer 243 for spindle apparatus, and is connected to the main control apparatus 242 in a line via the communication line 246. The 32 rotation speed control apparatuses 244 are connected in a line to this relay 245 via a communication line 251. The relay 245 relays control instructions output by the host CPU 236 so as to transmit the instructions to each rotation speed control apparatus 244.

[0067] During normal operation, the direct current transformer 243 performs the supply operation by converting a direct current voltage of 290 volts supplied via the direct current bus 247 to a direct current voltage of 24 volts, which is used as a control system voltage for the spindle driving motor 206.

[0068] Each of the above 32 rotation speed control apparatuses 244 for spindle drive motors is connected in series to the direct current transformer 243 for spindle apparatus via a control power supply line 249. Between each of the 32 rotation speed control apparatuses 244 and the direct current transformer 243 for spindle apparatus, there is a relay connector board 253. The control power supply line 249 is connected to the rotation speed control apparatuses 244 and the relay 245 from the direct current transformer 243 for spindle apparatus via the relay connector board 253. In addition, a control signal line 254 arranged along the machine from the host CPU 236 is connected to the rotation speed control apparatuses 244 and the relay 245 via the relay connector board 253. Further, two spindle drive motors 206 are connected to each rotation speed control apparatus 244. Each rotation speed control apparatus 244 can receive a control instruction via the communication line 246, the relay 245, and the communication line 251 so as to send feedback to control each spindle drive motor 206 independently based on the rotation speed detected by the rotation speed detector 250. That is, a single rotation speed control apparatus 244 is designed to drive and stop two spindle drive motors 206. Thus, each of the rotation speed control apparatuses 241 and 244 is designed to drive and stop each of the motors 204 and 206, respectively.

[0069] Now, essential aspects of the individual-spindle-drive type multi-twister 201 according to this embodiment will be described.

[0070] As shown in Figure 8, the above rotation speed control apparatus 244 for spindle drive motors has a problem judgment section 244a constituting a problem judgment means and a transmitting section 244b so as to detect problems such as incorrect yarn winding caused by the spindle apparatus 202 based on the rotation speed of the spindle drive motor 206.

[0071] An operating section (not shown in the drawings) is connected to the host CPU 236 so that an operator can set and input a judging ratio value (±3%). The host CPU 236 is designed to transmit this judging ratio value to each rotation speed control apparatus 244 via the communication line 246, the relay 245, and the communication line 251. The problem judgment section 244a of each rotation speed control apparatus 244 is designed to automatically set a normal range for the rotation speed of the spindle drive motor 206 based on the input judging ratio value and a preset target rotation speed so as to judge whether the rotation speed of the spindle drive motor 206 is within the normal range.

[0072] A transmitting section 244b is designed to transmit a warning signal to the relay 245 via the communication line 251 when the problem judgment section 244a determines the occurrence of problems. In addition, each relay 245 is designed to transmit a warning signal to the host CPU 236 when the relay 245 receives the warning signal. The warning signal includes a code indicating the number of the faulty spindles and a code indicating the cause of the problem.

[0073] The host CPU 236 is designed to display the occurrence of problems on a monitor 248 based on the warning signals received from each relay 245. On the monitor 248, for example, the number of the faulty spindle or the cause of the problem is displayed. In addition, on the monitor 248, a spindle rotation speed (rpm), the number of twists (T/M), yarn speed (m/min), and the predetermined length (m) is displayed.

[0074] The operation of the individual-spindle-drive type multi-twister 201 having the above configuration will be described with reference to the accompanying drawings.

[0075] As shown in Figure 6, a direct current voltage of 24 volts is supplied to each rotation speed control apparatus 244 from the alternating current power source 234 via the converter 235, the direct current bus 247, and the direct current transformer 243 for spindle apparatus. When an operator sets and inputs a judging rate value (±3%), the host CPU 236 transmits this judging rate value to each rotation speed control apparatus 244 via the communication line 246, the relay 245, and the communication line 251. The problem judgment section 244a of each rotation speed control apparatus 244 automatically sets a normal range for the rotation speed of the spindle drive motor 206 based on the judging rate valve and the target rotation speed.

[0076] Next, a start instruction is transmitted from the host CPU 236 to each relay connector board 253 via the control signal line 254, and is simultaneously transmitted from each relay connector board 253 to the rotation speed control apparatus 244 for spindle drive motors via the control signal line 255. Each spindle drive motor 206 is driven based on the instruction of each rotation speed control apparatus 244, and each rotary disk 233 rotates at a rotation speed identical to that of each spindle drive motor 206. When each rotary disk 233 rotates, the yarn Y unwound from the yarn supply package 208 enters the tension apparatus 232. The yarn Y is twisted once while a tension is applied thereto, and is further twisted. The yarn Y is then ballooned to the balloon guide 237.

[0077] On the other hand, a direct current voltage of 290 volts is supplied from the alternating current power source 234 to the rotation speed control apparatus 241 for the winding drum drive motor via the direct current bus 247. In addition, a start instruction is transmitted from the host CPU 236 to the rotation speed control apparatus 241 via the control signal line 254. The winding drum drive motor 204 is driven based on a instruction from the rotation speed control apparatus 241, its output is transmitted to the support shafts 218 and 223 and the reciprocating rod 228 via the pulleys 210, 212, 216, 219, 222, and 224, the belts 211, 214, 220, and 225, the decelerator 217, and the cam box 227. Then, the winding drum 221 for each spindle and the feed roller 226 rotate, and the traverse guide 229 of each spindle reciprocates.

[0078] When the winding drum 221 for each spindle and the feed roller 226 rotate and the traverse guide 229 for each spindle reciprocates, the yarn Y twisted twice by the spindle apparatus 202 is wound around the winding package P while the yarn Y is traversed by means of the traverse guide 229. During the traversing process, a winding angle is corrected by means of the decelerator 217.

[0079] Thus, while the yarn Y is wound around the winding package P, the rotation speed of the spindle drive motor 206 is controlled by feedback so as to maintain it to the preset value (target rotation speed). Nevertheless, if the above normal range is exceeded, the rotation speed control apparatus 244 for spindle drive motors detects a problem, immediately stops the motor 206, and transmits a signal to actuate the package brake (not shown in the drawings). When this package brake is actuated, the package P is lifted from the winding drum 221, and its rotation is stopped.

[0080] When a problem is detected, a warning signal is transmitted to the relay 245 via the communication line 251. When the relay 245 receives the warning signal, it transmits a warning signal to the host CPU 236 via the communication line 246. The host CPU 236 permits the monitor 248 to simultaneously display the number of the faulty spindle and the cause of the problem based on the received warning signal.

[0081] Thus, an operator can monitor problems for all

spindles simultaneously by watching the monitor 248 of the main control apparatus 242. Even in the case where a number of winding units U are provided in a line, the warning signal is temporarily relayed to each unit by means of the relay 245, thereby making it possible to prevent warning signal transmission errors and speedily transmit such signals to the host CPU 236 without fail.

**[0082]** The control power supply line 249 of the multi-twister 201 according to this embodiment is designed to supply a control system voltage (24 volts) for controlling the spindle drive motor 206 to each rotation speed control apparatus 244. In addition, the control signal lines 254 and 255 are designed to transmit a start instruction or a stop instruction to all rotation speed control apparatuses 241 and 244 and to transmit a simultaneous start signal or a simultaneous stop signal to all rotation speed control apparatuses 241 and 244 of ordinary machines. Further, the communication lines 246 and 251 are designed to monitor the rotation speed of each motor 206 and instruction values or the like to each motor 206 by means of the host CPU 236. The communication lines 246 and 251 then apply control parameters from the host CPU 236 to the rotation speed control apparatuses 241 and 244.

**[0083]** The above DC brushless motor incorporates a rotation speed detector 250 for detecting the motor's rotation speed. In addition, the problem judgment section 244a may change the rotation speed of the spindle drive motor 206, and determine problems based on variations in the instruction values (duty ratio) of the spindle drive motor 206.

**[0084]** The problem judgment section 244a and the transmitting section 244b according to this embodiment should preferably be provided not only for rotation speed control apparatus 244 for each spindle drive motors but also for the rotation speed control apparatus 241 for the winding drum drive motor.

**[0085]** In the first and second embodiments, although 32 rotation speed control apparatuses 44 and 244 for spindle drive motors (constituting unit control sections 9 and 209) are provided, the number of rotation speed control apparatuses 44 and 244 is not limited to 32. Likewise, although two spindle drive motors 6 and 206 are connected to the rotation speed control apparatuses 44 and 244 for the spindle drive motors, the number of spindle drive motors is not limited to 2. Further, although each yarn winding unit U is provided with the yarn supply packages 8 and 208, a plurality of such packages may be provided.

**[0086]** Although the multi-twister 1 and 201 according to the first and second embodiments composes double-twister in which two twists are applied by a single rotation of the spindle devices 2 and 202, a three-for-one or a four-for-one twisters may be used instead.

**[0087]** The present invention comprises an individual-spindle-drive type multi-twister having a spindle drive motor for every spindle for applying a twist to yarn, and this multi-twister drives each spindle drive motor via a rotation speed control apparatus, and forms a winding package from the yarn supply package provided for each spindle. Furthermore, the individual-spindle-drive type multi-twister has a yarn-run judgment means to determine whether yarn is running from the state of each spindle drive motor and a yarn length measuring means for performing yarn length measurement using the yarn running signal of the yarn-run judgment means.

**[0088]** Thereby, there is no need for a yarn filler to be used as an optical yarn-run detector, and thus it is possible to prevent malfunctions caused by fiber dust and reduce the manufacturing cost of the individual-spindle-drive type multi-twister. In addition, the present invention is also makes possible to eliminate a drop wire mechanism engaged with the running yarn to stop feeding the yarn from the yarn supply package if yarn is cut, thus making it possible to simplify the machine's structure.

**[0089]** The present invention is characterized in that the yarn-run judgment means determines whether the yarn is running from the load current value of each spindle drive motor.

**[0090]** Thereby, the presence or absence of spindle rotation is determined, making it possible to accurately determine whether the yarn is running.

**[0091]** The present invention is characterized in that it comprises a cutter means for cutting yarn that is being wound. The present invention also provides a full bobbin detection means for each rotation speed control apparatus. The full bobbin detection means outputs a cutter actuation signal to the cutter means when it detects a full bobbin winding package, and then outputs a spindle drive stop motor signal.

**[0092]** As a result, the present invention can stop spindle drive motors having full bobbin winding packages individually, making it possible to eliminate wasteful spindle rotation and wind yarn efficiently.

## Claims

1. An individual-spindle-drive type multi-twister having a spindle drive motor for every spindle to twist yarn, and each spindle drive motor is driven by means of a rotation speed control apparatus, and a winding package is formed from a yarn supply package provided at each spindle, characterized in that the twister has a yarn-run judgment means to determine whether yarn is running based on the state of each spindle drive motor, and a yarn length measuring means that performs yarn length measurement using the yarn running signal of said yarn-run judgment means.

2. An individual-spindle-drive type multi-twister as in claim 1, characterized in that said yarn-run judgment means determines whether yarn is running based on the load current value of each spindle

drive motor.

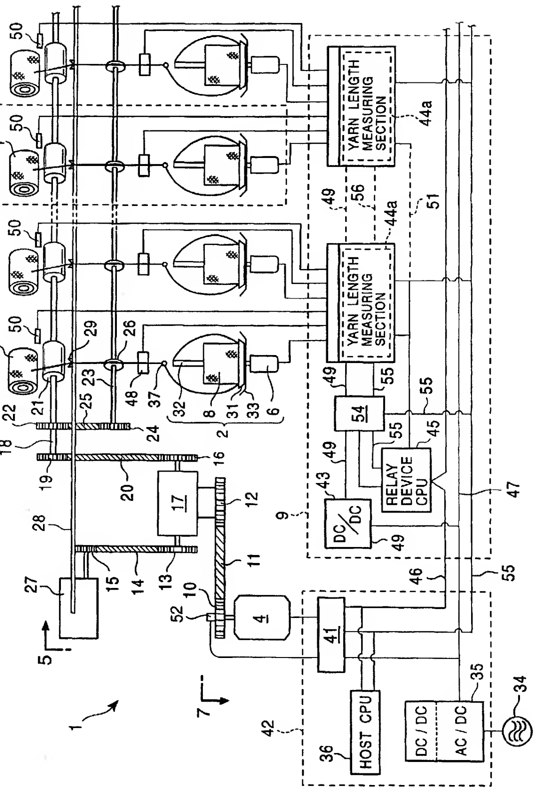
3. An individual-spindle-drive type multi-twister as in claim 1 or claim 2, characterized in that it comprises: a cutter means for cutting the yarn that is being wound, and a full bobbin detection means in the rotation speed control apparatus that outputs a cutter actuation signal and also outputs a spindle drive motor stopping signal if said yarn length measuring means detects that a winding package becomes a full bobbin.

4. An individual-spindle-drive type multi-twister as in claim 2 or claim 3, characterized in that said yarn-run judgment means sets a threshold value based on a load current value under a stable condition after the load current value of each spindle drive motor is stabilized, and detects the yarn breakage when the detected load current value exceeds its threshold value.

5. An individual-spindle-drive type multi-twister as in claim 2 or claim 3, characterized in that said yarn-run judgment means monitors the variation in load current value at a predetermined time, and detects the yarn breakage based on the scale of that variation.

6. An individual-spindle-drive type multi-twister as in claim 2 or claim 3, characterized in that said rotation speed control apparatus obtains an output of a instruction value based on the difference between a detected rotation speed and the target rotation speed for each spindle drive motor, and performs feedback control, and said yarn-run judgment means detects the yarn breakage by sudden fluctuations in the detected rotation speed or amount of output.

FIG. 1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YARN LENGTH MEASURING SECTION
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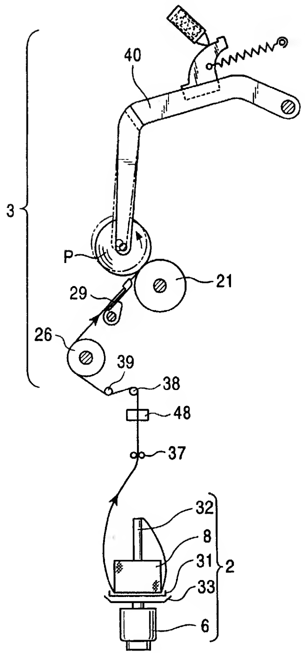
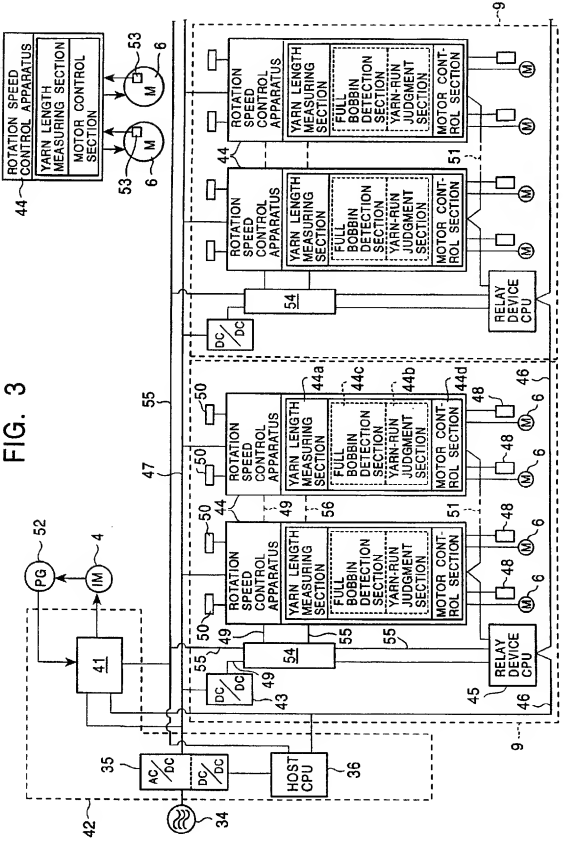
DC/DC
HOST CPU
DC / DC
AC / DC

FIG. 2

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MOTOR CONTROL SECTION
FULL BOBBIN DETECTION SECTION
YARN-RUN JUDGMENT SECTION
MOTOR CONT-ROL SECTION
RELAY DEVICE CPU
HOST CPU
AC/DC
DC/DC
PG
IM
M
41
54
4
6
9
34
35
36
42
43
44
44a
44b
44c
44d
45
46
47
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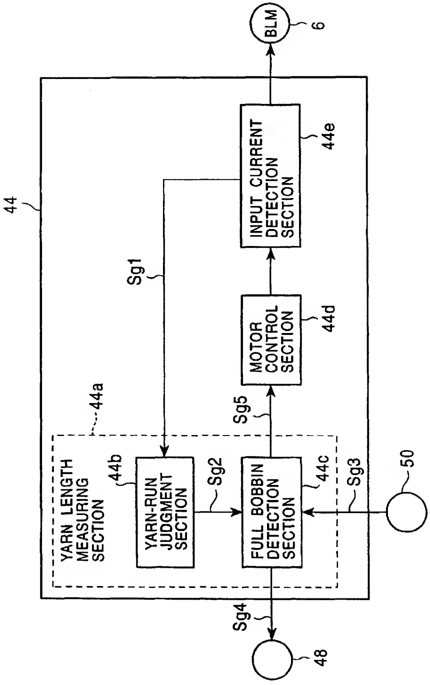
FIG. 3

FIG. 4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YARN LENGTH MEASURING SECTION
44a
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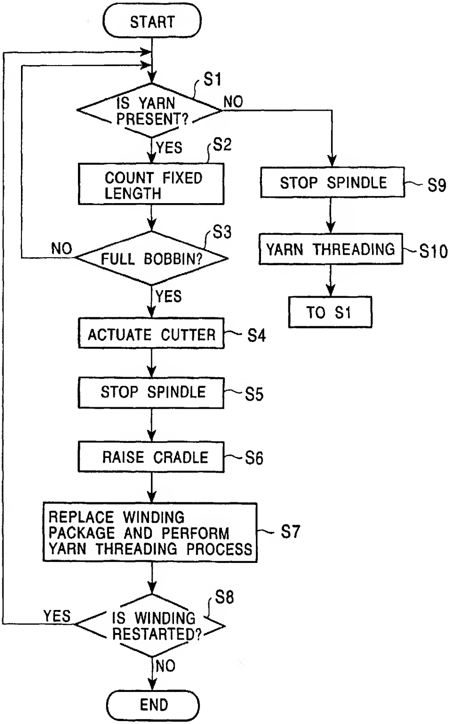
YARN-RUN JUDGMENT SECTION
Sg1
Sg2
FULL BOBBIN DETECTION SECTION
44c
Sg3
50
Sg4
48
Sg5
MOTOR CONTROL SECTION
44d
INPUT CURRENT DETECTION SECTION
44e
BLM
6

FIG. 5


START
S1
IS YARN PRESENT?
NO
YES
S2
COUNT FIXED LENGTH
S3
NO
FULL BOBBIN?
YES
ACTUATE CUTTER
S4
STOP SPINDLE
S5
RAISE CRADLE
S6
REPLACE WINDING PACKAGE AND PERFORM YARN THREADING PROCESS
S7
S8
YES
IS WINDING RESTARTED?
NO
END
STOP SPINDLE
S9
YARN THREADING
S10
TO S1

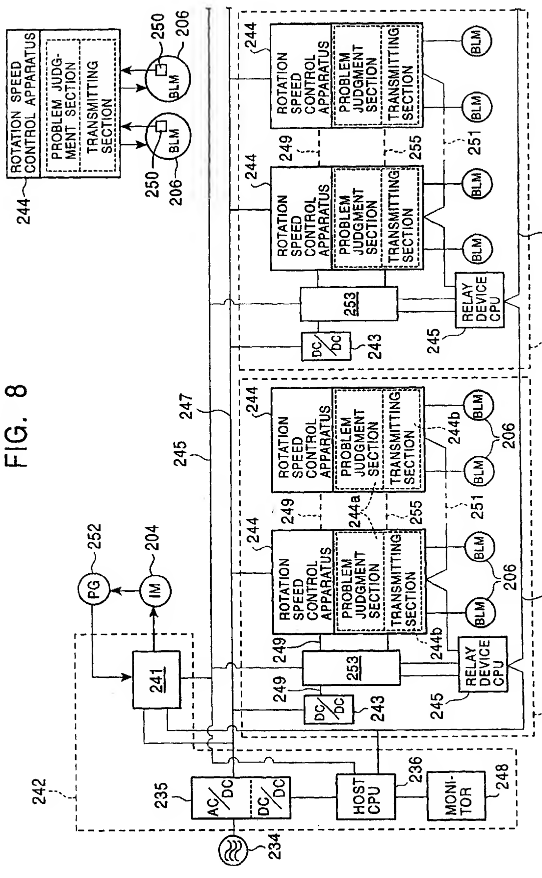
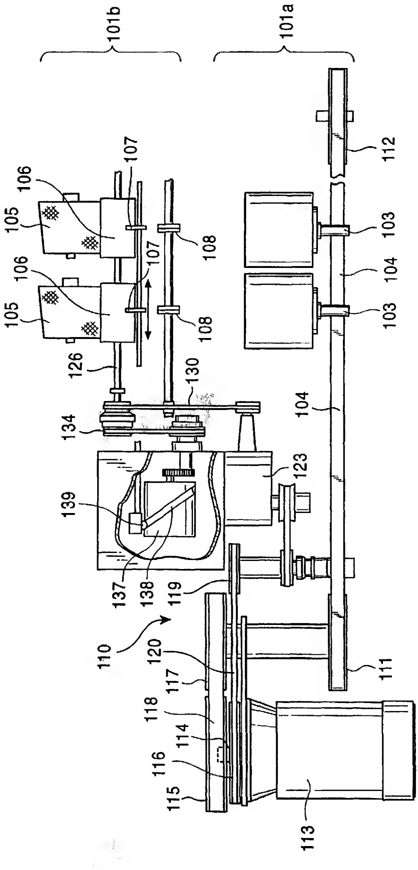

ROTATION SPEED CONTROL APPARATUS
PROBLEM JUDGMENT SECTION
TRANSMITTING SECTION
BLM
RELAY DEVICE CPU
253
DC/DC
241
PG
IM
AC/DC
DC/DC
HOST CPU
MONITOR
244
244a
244b
245
246
247
248
249
250
251
252
255
204
206
209
234
235
236
242
243

FIG. 8

FIG. 9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137
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FIG. 7

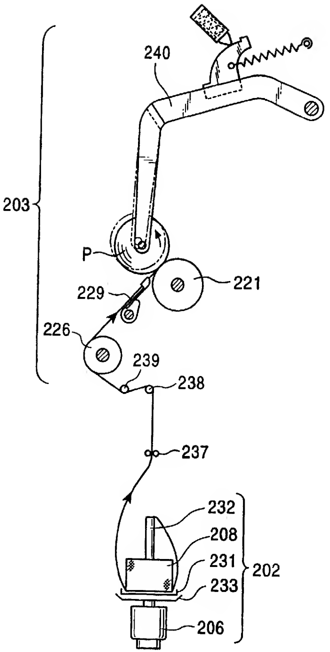
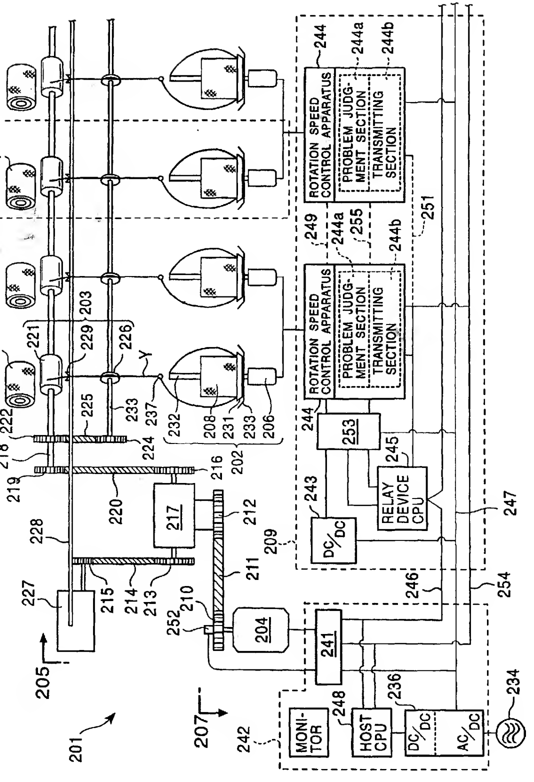


FIG. 6


ROTATION SPEED CONTROL APPARATUS
PROBLEM JUDG-MENT SECTION
TRANSMITTING SECTION
ROTATION SPEED CONTROL APPARATUS
PROBLEM JUDG-MENT SECTION
TRANSMITTING SECTION
RELAY DEVICE CPU
DC/DC
MONI-TOR
HOST CPU
DC/DC
AC/DC

European Patent Office

# EUROPEAN SEARCH REPORT

Application Number
EP 99 10 3544

| DOCUMENTS CONSIDERED TO BE RELEVANT | | | |
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| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int.Cl.6) |
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| | | | TECHNICAL FIELDS SEARCHED (Int.Cl.6) |
| | | | D01H<br>B65H |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| THE HAGUE | 5 July 1999 | Tamme, H-M |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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E : earlier patent document, but published on, or after the filing date
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L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

## ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 99 10 3544

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The members are as contained in the European Patent Office EDP file on
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05-07-1999

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82